FORGE

The International Journal of Forging Business & Technology

April 2007

A Supplement to Industrial Heating
THE INTERNATIONAL JOURNAL OF THERMAL TECHNOLOGY

A bnp media PUBLICATION

Welded Repairs Extend Forging Die Life

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Most forging die failures are caused by wear or cracks along edges and corners as a result of extreme and severe thermal stress. Specialized welding techniques, such as flood welding and overlay welding, can be used to repair and refurbish dies, often at minimal cost and substantial improvement in overall die life.

The welding materials available during the 1930s were totally inadequate for the forging applications of that period. At least it seemed that way to Matt Kiilunen, who eventually founded Weld Mold Company in 1945. As a commercial fisherman in Michigan's Upper Peninsula feeling the hard effects of the Depression, Matt found his way to Detroit, where he worked in a maintenance job at Huron Forge in the 1930s. He became known there as "Matt the Welder." Based on the high-impact and severe-heat applications in the forge, Matt developed welding processes using superior materials that retained the toughness and hardness required to greatly extend the life of hammer and press dies.

Along with other processes for welding dies, Matt and his company developed "flood welding" and the "Weld Mold process" using large-diameter electrodes to greatly increase welding deposition rates. This enables the forge to get broken dies repaired and back in operation quickly. Flood welding is particularly suited for repairs on large dies, hammers, rams, sow block, columns, heads and other forging equipment components. Today Weld Mold manufactures over 3,000 products and sizes, not solely for the global forging industry, but for all specialty welding applications.

In most cases, the welding of dies and forging equipment offers substantial savings for the forge by providing lower tooling costs and timely delivery. The major costs of any forging plant are raw material, labor, die costs and energy costs. Tool steels for dies run 20-30% of the total cost of any forged part. It is this aspect of the costs that we address with welding, often providing overall improvement of 4-6% in bottom-line performance.

Figure 1. Weld Mold founder Matt "The Welder" Kiilunen, deceased in 1990, could often be found at his workbench working on his specialty welding techniques.

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CAUSES OF DIE FAILURES

The majority of die failures is caused by wear or cracks along the edges and corners as a result of extreme and severe thermal stress. This is true for hammer, press and up-setter applications. Axle dies, crankshaft dies and other deeply tapered dies show severe cracking in the root of the impression, often through the bottom of the die, which is caused by the high compressive forces of the material as it is being forced into the tight die configuration.

Hammer die life is determined by the total mass of the die. Hammer dies are typically recut three to four times for continued use. Production of the die may be reduced progressively after each recut. As the block mass is reduced, failures will occur as fractured die blocks, shanks, locks or other features. Eventually, they will require replacement of the die and result in losses in machine time and downtime.

> Optimum die life will be found, in all applications, by the choice of the welding alloy that will prevent premature wear while preventing crack formation due to excessive hardness.

Press die life is dependent on extended and sustained levels of extreme thermal abrasion. Press dies require regular maintenance and a minimum shut-height, though they are not as dependent upon the mass of the die for strength as are hammer dies. As with hammer dies, press dies will be progressively recut to eliminate wear and fractures and will show the same losses as with hammer dies. Press-die replacement may not be as expensive as hammer die replacement, but losses still accumulate for downtime, additional machine time and in costs for the replacement of the high-alloy block steel.

Up-setter applications have replacement dies of high-grade tool steels similar in content to AISI H-grade tool-steel alloys. Their replacement is determined by their time in service records and their repeat job history. While some up-setter dies are recut, they are typically replaced with new dies once a cycle has been reached that has been proven to provide the expected die life. These dies can also be repaired by welding using the proper procedures and welding material, allowing continuous use of the same dies. Often it is more economical to replace the smaller dies than to weld them.

Forge and press equipment components will develop fractures that can disable a forge operation and pose a dangerous situation in the forge. Cast-steel columns, rams, vee's, sow blocks, tie plates, cylinders, bases and press frames can be successfully repaired expediently and at relatively low cost. Consequently, repaired equipment can be put back in operation quickly, improving the forge's productivity.

WELDED REPAIRS

Given the causes and types of forging-equipment failures, specialized welding techniques can be used to repair dies and extend their lives. All welding repair jobs need four things:

- Proper equipment
- Skilled welding personnel
- Documented and followed procedures
- Correct welding materials

When wear is the main factor in die life, a higher alloy welding material of greater hardness than the base material of the die block can be utilized. When cracking is the problem, a lower alloy material must be specified. The lower alloy material must be designed to provide the highest characteristics of toughness and hardness to provide extended life of the die block. Optimum die life will be found, in all applications, by the choice of the welding alloy that will prevent premature wear while preventing crack formation due to excessive hardness. Hammer dies require different alloys than press dies, which require different materials than up-setter dies. The same is true for forging-equipment components.

For any given repair scenario, it is helpful to take specific data for the specific application and complete an analysis of the costs involved in conventional die preparation: recuts, fly cutting, re-sinks, changeover and downtime. With this done, compare those costs to welding. As an example, a 6-ton hammer die – after four re-sinks (weight of 2.5-3 tons) – will be scrapped. With welding, this "scrap" die can be used indefinitely. Welding, through the use of the proper process and materials, will eliminate or drastically reduce the amount of scrap that fills the yard. Of course the analysis of component welding is simply comparing the cost and delivery time of a new item versus the same to weld the existing piece. The cost of most die or component repairs will run one-third to one-half that of newly purchased assets, with delivery time measured in weeks rather than months or years.

Figure 2. The operational sequence for the repair of a severely cracked forging hammer base: a) the fractured base before repair; b) workman repairs hammer base using Weld Mold's welding arm apparatus; and c) the finished repair.

HOW WELDING BENEFITS THE FORGE

Within the context of this article, there are three welding techniques that will benefit the forge:

- Overlay welding on the high stress zones of the dies, an example of which would be the radii inside the impression, using a "slippery" higher alloy material.
- Overlay the complete die impression with a higher alloy material or with layering a series of materials designed specifically for all the operating characteristics of the die configuration. Often this requires a significant amount of trial and error to achieve the best results, but success can result in tremendous die life increases.
- Scarfing out the old impression and flood welding with a large-diameter electrode or cored wire designed for hardness and wear, specified for the exact application of the hammer or press dies.

Weld Mold developed and perfected the use of flood welding in more than 60 years serving the forging industry. The use of this technique reduces the application cost of welding by as much as 90% of that of the overlayering method, offering tremendous savings in labor and turnaround time. Not every job is suited for flood welding, however. All three methods are necessary in any successful welding program and each has their appropriate use.

Typical flood-welding applications utilize up to 0.75-inch-diameter electrodes with chemistry designed to meet the toughness and hardness requirements of hammer- and press-forging applications. Deposition rates can exceed 60 lb/hr (27 kg/hr) of solid weld metal while providing comfortable operating conditions for the welder. Large impressions, bases and rams, and sow blocks can be repaired in hours, where other methods may take days, weeks or even months.

Historical results have shown that the performance of welded dies increases the original life of the die block by a minimum of 50% more than its original life. Typical recuts or re-sinks require all features to be lowered, but by using flood welding it is not necessary to recut the busters and blockers unless these features are worn to the point that weld repair is necessary. On a front-axle flood-welded die, the buster and blocker displayed a life 10 times that of the finished impression. Flood welding eliminates the re-sink requirement of all the features of the die, extending the life of the die and greatly reducing machining and downtime costs.

TO WELD OR NOT TO WELD?

The decision to systematically use welding should be made taking the following points into consideration:

- High-volume tooling offers the greatest payback for welding.
- Welded die life may increase production by 50-100% or more.
- Welded repairs mean reduced machining and downtime.
- Welded die blocks can be constructed of lower cost materials.
- Die-block height is maintained, mass is maintained and shims eliminated.
- Only worn features are repaired. It is not necessary to re-machine all top features.
- Fly cutting is greatly reduced or eliminated.
- Welded die blocks require only post-weld tempering, eliminating heat treatment.
- Tooling can be reused indefinitely, and die-block scrap is reduced or eliminated.
- Welded blocks may eliminate the necessity of nitriding or other surface treatments. However, weld metal responds well to all surface treatments.

Figure 3. Flood-welded press die ready for machining.

Figure 4. Aerial view of Weld Mold's Brighton, Mich., headquarters. The company also has operations in Italy and South Korea.

CONCLUSION

The use of the proper products and processes ensures success in welding die blocks and forging-equipment components. The value of welding is reduced costs, improved turnaround time and keeping this industry competitive. Matt Kiilunen invented and developed the flood-welding process more than 60 years ago, and through its use we continue to prove our expertise in forge die welding and equipment reclamation worldwide.

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